

1    WHAT IS CLAIMED IS:

2

3    1. A method for hydroprocessing a hydrocarbon feedstock, said method  
4    employing multiple hydroprocessing zones within a single reaction loop,  
5    each zone having one or more catalyst beds, comprising the following  
6    steps:

7

8    (a) passing a hydrocarbonaceous feedstock to a first hydroprocessing  
9    zone having one or more beds containing hydroprocessing  
10   catalyst, the hydroprocessing zone being maintained at  
11   hydroprocessing conditions, wherein the feedstock is contacted  
12   with catalyst and hydrogen;

13

14   (b) passing the effluent of step (a) directly to a hot high pressure  
15   separator, wherein the effluent is contacted with a hot, hydrogen-  
16   rich stripping gas to produce a vapor stream comprising hydrogen,  
17   hydrocarbonaceous compounds boiling at a temperature below the  
18   boiling range of the hydrocarbonaceous feedstock, hydrogen  
19   sulfide and ammonia and a liquid stream comprising  
20   hydrocarbonaceous compounds boiling approximately in the range  
21   of said hydrocarbonaceous feedstock;

22

23   (c) passing the vapor stream of step (b) after cooling and partial  
24   condensation, to a hot hydrogen stripper containing at least one  
25   bed of hydrotreating catalyst, where it is contacted countercurrently  
26   with hydrogen, while the liquid stream of step (b) is passed to  
27   fractionation;

28

29   (d) passing the overhead vapor stream from the hot hydrogen  
30   stripper/reactor of step (c), after cooling and contact with water, the  
31   overhead vapor stream comprising hydrogen, ammonia, and  
32   hydrogen sulfide, along with light gases and naphtha to a cold high  
33   pressure separator, where hydrogen, hydrogen sulfide, and light

hydrocarbonaceous gases are removed overhead, ammonia is removed from the cold high pressure separator as ammonium bisulfide in the sour water stripper, and naphtha and middle distillates are passed to fractionation;

- (e) passing the liquid stream from the hot hydrogen stripper/reactor of step (c) to a second hydroprocessing zone, the second hydroprocessing zone containing at least one bed of hydroprocessing catalyst suitable for aromatic saturation and ring opening, wherein the liquid is contacted under hydroprocessing conditions with the hydroprocessing catalyst, in the presence of hydrogen;
- (f) passing the overhead from the cold high pressure separator of step (d) to an absorber, where hydrogen sulfide is removed before hydrogen is compressed and recycled to hydroprocessing vessels within the loop; and
- (g) passing the effluent of step (e) to the cold high pressure separator of step (d).

22 2. The process of claim 1, wherein the hydroprocessing conditions of  
23 step 1(a) comprise a reaction temperature of from 400°F-950°F  
24 (204°C-510°C), a reaction pressure in the range from 500 to 5000 psig  
25 (3.5-34.5 MPa), an LHSV in the range from 0.1 to 15 hr<sup>-1</sup> (v/v), and  
26 hydrogen consumption in the range from 500 to 2500 scf per barrel of  
27 liquid hydrocarbon feed (89.1-445 m<sup>3</sup> H<sub>2</sub>/m<sup>3</sup> feed).

29 3. The process of claim 2, wherein the hydroprocessing conditions of  
30 step 1(a) preferably comprise a temperature in the range from  
31 650°F-850°F (343°C-454°C), reaction pressure in the range from  
32 1500-3500 psig (10.4-24.2 MPa), LHSV in the range from 0.25 to

1        2.5 hr<sup>-1</sup>, and hydrogen consumption in the range from 500 to 2500 scf  
2        per barrel of liquid hydrocarbon feed (89.1-445 m<sup>3</sup> H<sub>2</sub>/m<sup>3</sup> feed).

3

4        4. The process of claim 1, wherein the hydroprocessing conditions of  
5        step 1(e) comprise a reaction temperature of from 400°F-950°F  
6        (204°C-510°C), a reaction pressure in the range from 500 to 5000 psig  
7        (3.5-34.5 MPa), an LHSV in the range from 0.1 to 15 hr<sup>-1</sup> (v/v), and  
8        hydrogen consumption in the range from 500 to 2500 scf per barrel of  
9        liquid hydrocarbon feed (89.1-445 m<sup>3</sup> H<sub>2</sub>/m<sup>3</sup> feed).

10

11        5. The process of claim 4, wherein the hydroprocessing conditions of  
12        step 1(e) preferably comprise a temperature in the range from  
13        650°F-850°F (343°C-454°C), reaction pressure in the range from  
14        1500-3500 psig (10.4-24.2 MPa), LHSV in the range from 0.25 to  
15        2.5 hr<sup>-1</sup>, and hydrogen consumption in the range from 500 to 2500 scf  
16        per barrel of liquid hydrocarbon feed (89.1-445 m<sup>3</sup> H<sub>2</sub>/m<sup>3</sup> feed).

17

18        6. The process of claim 1, wherein the feed to step 1(a) comprises  
19        hydrocarbons boiling in the range from 500°F to 1500°F.

20

21        8. The process of claim 1, wherein the feed is selected from the group  
22        consisting of vacuum gas oil, heavy atmospheric gas oil, delayed coker  
23        gas oil, visbreaker gas oil, FCC light cycle oil, and deasphalted oil.

24

25        9. The process of claim 1, wherein the cetane number improvement  
26        occurring in step 1(e) ranges from 2 to 15.

27

28        10. The process of claim 1, wherein the hydroprocessing catalyst comprises  
29        both a cracking component and a hydrogenation component.

30        11. The process of claim 10, wherein the hydrogenation component is  
31        selected from the group consisting of Ni, Mo, W, Pt and Pd or  
32        combinations thereof.

- 1 12. The process of claim 10, wherein the cracking component may be
- 2 amorphous or zeolitic.
- 3 13. The process of claim 12, wherein the zeolitic component is selected from
- 4 the group consisting of Y, USY, REX, and REY zeolites.
- 5
- 6 14. The process of claim 1, wherein the second hydroprocessing zone of
- 7 step 1(e) is maintained at the same pressure as the first
- 8 hydroprocessing zone of step 1(a).